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STATE OF THE ART DEVELOPMENTS IN ESTABLISHED CAI EFFORTS --- THE TICCIT SYSTEM

by

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ABSTRACT

State of the Art Developments in Established CAI Efforts — The TICCIT System

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This paper, presented at a symposium on computer-based instructional systems at the 1982 meeting of the American Educational Research Association in New York City, discusses innovations in the TICCIT computer-based instructional system. Specific issues addressed include innovations in the system's authoring languages, integration of videodisc technology, instructional management systems, creation of color computer graphics using a digitizing document camera, and two-dimensional simulations of instrument panels. Additional topics include a discussion of educational and psychological research that has influenced design and use of the system and planned developments in the system in the next two to three years.

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Hazeltine Corporaton

The format for this session required that we respond to the following questions:

1. How has TICCIT changed during the past 3-5 years?
2. What educational and psychological research has influenced design and/or implementation changes in the products offered?
3. What R&D thrusts within Hazeltine suggest future applications, hardware or software in the field of instructional applications of computers?

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1. TICCIT has changed in several very fundamental ways in the past 3-5 years. Among them:

   a. TICCIT now supports two authoring systems. The first, Authoring Procedure for TICCIT (APT) is the original TICCIT authoring system (although extensively revised) which reflects the RULE, EXAMPLE, PRACTICE, instructional design strategy and is an integral part of the system. The second, TICCIT Authoring Language (TAL) is a general purpose language. TAL permits the author to define the function of TICCIT's learner control keys in any way he or she desires. Authors, therefore, are not restricted to commands developed for instructional applications

or by a particular predefined model of the instructional or learning process.

TAL was created to provide a means of authoring instructional sequences and simulations that did not fall within the RULE, EXAMPLE, PRACTICE framework. TAL is a result of research concerning the design of courseware and the recognition that a "free form" authoring language is needed to deal with the variations in courseware that can never be fully anticipated.

TAL provides the author with up to four specialized editor packages for each display the student sees. The first page the author sees is called a base page upon which text, formatted and colored exactly as it will be presented to the student, is entered. Here the author simply types the display as the student should see it. The second editor that the author may use is called the display specifications page. Here the author may enter commands used to display additional text when specified conditions have been met or may identify a graphic and give its coordinates for display to the student. This page may also be used to define windows that make use of the light pen possible. The third page available to the author contains the branch table. This table is used to define branching by the TICCIT keyboard's learner control keys, which allow the student to branch to any other TAL display in the program, as specified or limited by the author. The fourth page avalable to TAL authors is the response analysis page. This page is used to specify how

the TICCIT system will respond to student input, whether it takes the form of a touch of the light pen, typed text, an algebraic expression, etc. It also allow the author to compute, display, or store any variables needed for scoring, simulations, or other conditional functions. authors makes possible the great flexibility of the TICCIT system in applications such as procedural training simulations and videodisc sequences.

b. TICCIT is now capable of incorporating videodisc displays into its instructional courseware in addition to the videotape capabilities it has had since its inception. The TICCIT display can show either full color videodisc images or computer-generated text and graphics on the same screen.. Existing TICCIT authoring languages provide complete programming support for integrating instructional videodisc sequences into the computer-based instructional system. No special modifications are required. Authoring TICCIT instructional materials that require videodisc sequences is as easy as authoring standard TICCIT CAI instruction.

c. TICCIT is now used as a training device which incorporates 3-dimensional instrument panels and hardware components . As TICCIT generates test readings, the interfaced 3-D hardware can be probed with test equipment. This combination of CAI and 3-D hardware provides a very high fidelity simulation of equipment tests. This approach has been taken in the design of the Navy's MK 92 training system. Where

instructional analysis indicates that the student would learn better by use of actual or simulated instruments and test equipment with supporting instruction and prompting provided by the TICCIT screen display, that approach was taken. Training objectives that do not require extremely high fidelity are presented by TICCIT alone.

d. TICCIT now supports a full range of student management programs that provide immediate on-line data to instructors concerning individual student or class performance. Such reports are also available in hard copy. Specific reports include:

1. An individual student report that indicates the lesson(s) worked on, the dates the lesson(s) were started and ended, the amount of time students spent on lessons, the mean time spent by class members, the number of times students took the test, individual scores by the student on the lesson tests, and mean score for the class members on all lessons.
2. An individual student report on test results that indicates file label of the test, test date, time the student spent on the test, test criterion, number of items answered correctly, total number of items attempted percent correct, and student and class means.
3. A class report showing the students' names, identification numbers, time spent on the lessons, lessons passed, scores on the lesson tests, and class means for the time and score.
4. A class report showing the students' names, identification

numbers, time spent by the students on the course, number of lessons passed in the course, and class averages for time spent in the course and lessons passed.

5. An item analysis report showing each practice or test item, the percentage of students answering that item correctly, the number of unanticipated answers to the question, and up to 24 occasions codes. These occasion codes are used by authors to identify any particular category of student response that may be of interest. For example, the author of a lesson on mathematics may wish to know the number of times each multiple choice option was selected for each test question. For each item on the test, 24 such author defined occasion codes exist. This capability makes it possible for courseware authors to identifty the particular types of problems students are having and thereby identify problems in the instruction or test. Revisions to courseware can then be evaluated by determining whether or not the problems identified through the use of the occasion codes have been eliminated.

6. TICCIT also logs all student end-of-message key presses and the time between them. These extremely detailed data on student performance are recorded on the system logging tape. A variety of existing data reduction programs can be used to evaluate courseware using this information and new programs can be designed to extract data of interest for new applications. Logging tape data, like the

data gathered through the use of occasion codes, are extremely useful during the courseware revision process. If, for example, the data revealed that a majority of students were spending a great deal of time studying a particular display, it might indicate that the contents of that display are not presented clearly.

TICCIT also supports a variety of batch class reports and, report support facilities including, class roster builder, update of Unit/Lesson Averages, Update Class/Test Averages.

e. TICCIT is now equipped with a Hamamatsu document camera that allows graphics drawn by illustrators to be scanned into the TICCIT system in about two minutes and then, using an on-line graphics editor package, be edited be colored, rotated, expanded, reduced, moved, etc. as required. The graphics editor can also be used to create unique symbols or characters which can be assigned to keys on the keyboard and stored for subsequent use. TICCIT's unique data storage design makes it possible for TICCIT to provide graphics that are displayed instantaneously as one image rather than drawn slowly as the student watches. In situations that require the use of complex graphics, this high speed graphics display capability is critical to maintaining student interest, teaching complex materials, and supporting complex text. In addition, the ease with which one can construct graphics makes it possible to staff courseware departments with graphics illustrators rather than computer programmers.

f. TICCIT is now used for realistic part-task procedural simulations using interactive color graphics and videodisc presentations. Such simulations include, but are not limited to:

1. instrument panels
2. controls (manual and electronic)
3. psychomotor tasks (eg. assembly procedures)

TICCIT's graphic capabilities coupled with videodisc sequences can provide great realism in two dimensional simulations. The ability to revise the computer generated graphics and text and the ability of the computer to analyze student's inputs in a variety of formats far surpasses the capabilities of any videodisc system alone, but the random access to single frames of video and the ability to show sequences of motion within an instructional segment make videodisc an excellent peripheral to TICCIT.

g. TICCIT is now available in a compact, "ruggedized" version and is programmable as a maintenance and troubleshooting job-aid. A prototype of this TICCIT configuration is now at sea on a Navy Spruance class destroyer. This system is designed to make available to novice technicians the technical expertise of a Navy Senior Chief through the use of a computerized data base of troubleshooting logic in the form of a job-aid. As used in this setting, TICCIT will allow inexperienced technicians to locate and repair ship system malfunctions by simply responding to questions posed by TICCIT and by following specified

procedures. The question to be answered will be whether the system can provide the troubleshooting and maintenance information required by school-trained, but inexperienced, technicians to troubleshoot and maintain the ship's MK 86 fire control system.

h. Finally, TICCIT has become a mature, reliable CAI system with a record of solid performance. It is long past the stage of being an experimental system. There are now thirteen TICCIT systems in regular use, providing instruction on a daily basis to thousands of students. Additional TICCIT systems are currently under production for existing contracts. TICCIT systems are also configured in different ways depending on the requirements at any given particular site. The TICCIT systems now in the field range have one, two, three, or more processors configuring from two to more than five hundret terminals. Storage capacity ranges from 25 megabytes to 1000 megabytes, all with the same courseware and software capabilities. A DBMS interface at two TICCIT sites allows an interface between the TICCIT systems' computer-managed instructional software packages and other CMI packages written in COBOL, AOS, etc.

2. Educational and Psychological Research

TICCIT is the only computer-based instructional system designed with both a built-in RULE, EXAMPLE, PRACTICE instructional model and learner-control. These capabilities are reflected in the hardware design of the keyboard, the software structure of the Authoring Procedure for TICCIT (APT) and in most of the

courseware designed for delivery on the system. This concern for instructional design and related educational and psychological research continues to the present.

One recent example of the impact of educational and psychological research on a TICCIT project is that of the U.S. Navy's NOMAD program. This program was designed to provide a solution to the problem of providing maintenance in for complex systems in the field. Paper documentation for troubleshooting and repair of such systems has grown to such an extent that it is often impossible to locate the appropriate section of the document required for isolating and correcting a fault. Paper-based documentation is hard to update and often is written and illustrated at an extremely complex level. Therefore, it is often hard for the technician to read and understand.

Naval Sea Systems Command has sponsored an effort to provide a solution to this problem by providing technicians at sea with a computer-based job-aid based on the TICCIT system concept. The hardware for the system consists of a Data General NOVA 4 computer, 1.26 megabyte floppy-disk-drive, 25 megabyte winchester disk, color CRT, lightpen, and keyboard. The hardware is about the size of a four drawer file cabinet.

The application of educational and psycological research to this problem lies in the area of designing the troubleshooting logic and procedural text and graphics required by technicians to perform the required troubleshooting and maintenance operations. Bond and Towne (1979) provided a good starting point for this effort. In their research, Bond and Towne identified several types of

information thought to be critical to troubleshooting. Their recognition that troubleshooting is an abstract mental process, not one of "being good with ones' hands", led us to explore a broad body of psychological research dealing with cognitive processes. Our own research on the cognitive structures and processes required to execute procedures based on instructions was also helpful.

The resulting troubleshooting and maintenance aiding system implemented on the NOMAD system provides the maintenance technician with text and graphic displays that provide the necessary contextual knowledge, logical troubleshooting procedures, checks and adjustments that are required to rapidly isolate and correct a fault. Preliminary results indicate that this approach can dramatically decrease the time and human resources required to troubleshoot a complex electro-mechanical system.

NOMAD is currently gathering information on the troubleshooting strategies its users employ by tracking their individual use of the on-line maintenance material. Subjective comments are also being collected through the use of the NOMAD system's NOTE function, which allows users to comment on any aspect of the troubleshooting program, indexing user comments to that part of the program where they made the comment.

NOMAD is only one example of how state of the art educational and psychological research is being used to influence the development of TICCIT and TICCIT courseware.

Another example of the application of research to the improved design of

TICCIT courseware is in the area of hypertext. Hypertext is an old concept that we are exploring as a means of providing improved procedural instruction (directions) assembly tasks. Hypertext, in this particular application, consists of a set of directions for putting together a small model. These directions have no illustrations and are written at the fourth grade level.

On each page of the directions, there is a single green square and one or more cyan squares. Persons reading the directions need only touch any word in the directions to see another display designed to explain more fully what that word means or what the operation described looks like. For example, if the word is "assemble", the branch might lead to a page that shows the parts of the model to be assembled and includes arrows and text designed to make the meaning of the word assemble unmistakably clear in its application at this stage of assembling the model.

If readers wants to view the completed model, they need only touch the green box on each page of the directions. A graphic illustration of the completed model is then displayed. At this point, readers have even more options. They can touch any part of the graphic of the completed model and then be shown a blown-up graphic of that part of the model. Touching this graphic reveals an illustration of the parts which are used to put it together and how they are to be assembled.

Readers also have the ability to request different views of the model, its subassemblies, and their parts in the graphics only mode. A touch of a key will show readers how the component looks from any of six different angles.

Although the hypertext research we are conducting is still in its early stages, some preliminary findings are of interest. For example, when the directions for this task are presented to people on paper (both text and graphics), about two thirds of the people make mistakes in doing the task which they never recognize to be mistakes. However, when people are asked to do the assembly task using the hypertext, they don't seem to make mistakes. In fact, no subjects in our research have made any mistakes on this task when hypertext was available. Even though this is a preliminary finding, we are encouraged to believe that this approach will be of particular value for presenting instructions for tasks that are extremely dangerous, such as working with equipment which carries high voltage.

3. R&D Thrusts suggesting Future Applications, Hardware, and Software For Instruction

Future plans for TICCIT include:

a. Full graphic overlay capability with videodisc permitting computer-generated text and graphics to be superimposed over NTSC video displays

b. A stand-alone microprocessor version of the system, for courseware delivery to isolated users, but configured to permit data collection from these isolated geographic areas at a central location

c. Interface with synthetic speech

d. An "intelligent" advisor

e. Development of practical methods to improve authoring efficiency and

further reduce the cost of CAI courseware development.

f. Development of simplified, built-in paradigms for design of procedural training materials and procedural job-aids.

Full graphic overlay capability with videodisc -

At the present time, TICCIT provides for completely interactive video in the tape or disc format. However, Hazeltine's work in this area is continuing. Now, TICCIT either shows NTSC video or displays computer-generated graphics. We plan to have full-screen graphics overlay on video within the near future. This capability will enable us to use TICCIT's graphics capabilities to highlight video images using color, to add text, to add cues to prompt the student in videodisc simulations, etc.

A micro-processor version of the system -

Although TICCIT in its present configuration is ideal for school settings, there are applications which call for delivery of computer-based instruction to small numbers of students in remote areas. In such cases, it is important to be able to down load courseware from larger TICCIT systems onto micros. This capability make TICCIT an even more desirable delivery system for training on ships, in rural areas, or even in submarines.

Voice recognition and audio output -

Voice recognition can provide an improvement in training realism and "user friendliness." This is an emerging technology in which the specific characteristics required for training have a major impact on system design. This technology promises to offer a device which will serve as a TICCIT

peripheral.

Audio output has been an available TICCIT feature since the system's earliest implementation, and this facility is in use at some current TICCIT installations. While the authoring software already supports audio output, digital audio and videodisc supplied audio represent currently available system options. Evaluation of the degree of fidelity desirable in such output is currently being investigated. High fidelity, if required for a training, or educational application may soon be available.

An "intelligent" Advisor -

TICCIT currently has a system advisor that interrupts students when they take actions that are unexpected or that are identified by advisor logic as poor learning strategies. This advisor recommends, rather than forces corrective measures and therefore can be ignored by the student. An innovation currently under study is that of designing logic for an advisor that will identify different student learning styles and strategies and that will respond individually to the student depending on these factors and on his or her performance on specific types of learning tasks. Such an advisor need not wait until the advent of truly "intelligent" computers. Work on this project is in its preliminary stages.

Development of a third authoring system -

The third authoring system would be designed to further reduce the cost of CAI courseware development. It would include an expanded system of prompts to facilitate data entry by authors who have no programing training and need only

limited capabilities of the system.

Development of simplified, built-in paradigms for the design of procedural training materials and procedural job-aids - The NOMAD program has taught

The NOMAD program has taught us much about the design of computer-based jobaids, as has our research with hypertext. One of the products of these efforts has been a model which will be reflected in software for a fourth TICCIT language, designed to facilitate authoring of this new type of courseware.